(12) UK Patent Application (19) GB (11) 2 305 683 (13) A

(43) Date of A Publication 16.04.1997

(21) Application No 9700421.2

(22) Date of Filing 01.06.1994

Date Lodged 10.01.1997

(62) Derived from Application No. 9410983.2 under Section 15(4) of the Patents Act 1977

(51) INT CL[6]
E21B 29/00 33/13

(52) UK CL (Edition O)
E1F FJU FLA

(56) Documents Cited
GB 2279092 A GB 2275282 A US 4688640 A
US 4339000 A

(58) Field of Search
UK CL (Edition O) E1F FJU FLA
INT CL[6] E21B
Online: WPI

(71) Applicant(s)
Philip Head
6 Leith Mansions, Grantully Road, LONDON, W9 1LQ, United Kingdom

(72) Inventor(s)
Philip Head

(74) Agent and/or Address for Service
Hillgate Patent Services
No 6 Aztec Row, Berners Road, LONDON, N1 0PW, United Kingdom

(54) Method of abandoning a well

(57) The invention relates to a method of abandoning a well which has ceased to provide economic use. The method includes the steps of perforating all the well conduits (except the outermost conduit) at the point the well is to be abandoned; purging the fluid from the annular channels between the conduits up the central channel by applying a gaseous medium, such as nitrogen, at A; and sealing the channels e.g. with cement. The perforated conduits can then be cut above the cement plug and removed.

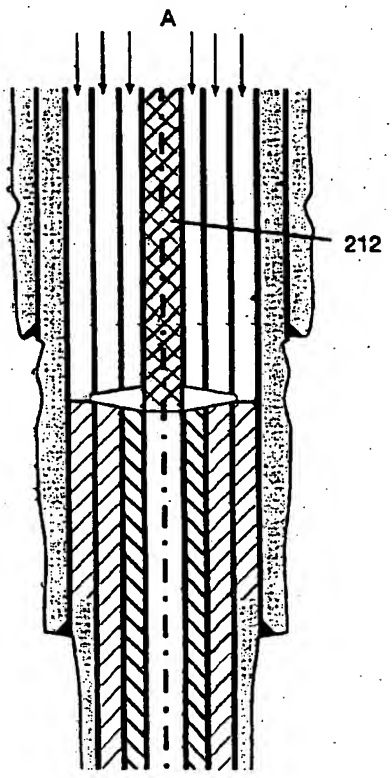

Figure 16

GB 2 305 683 A

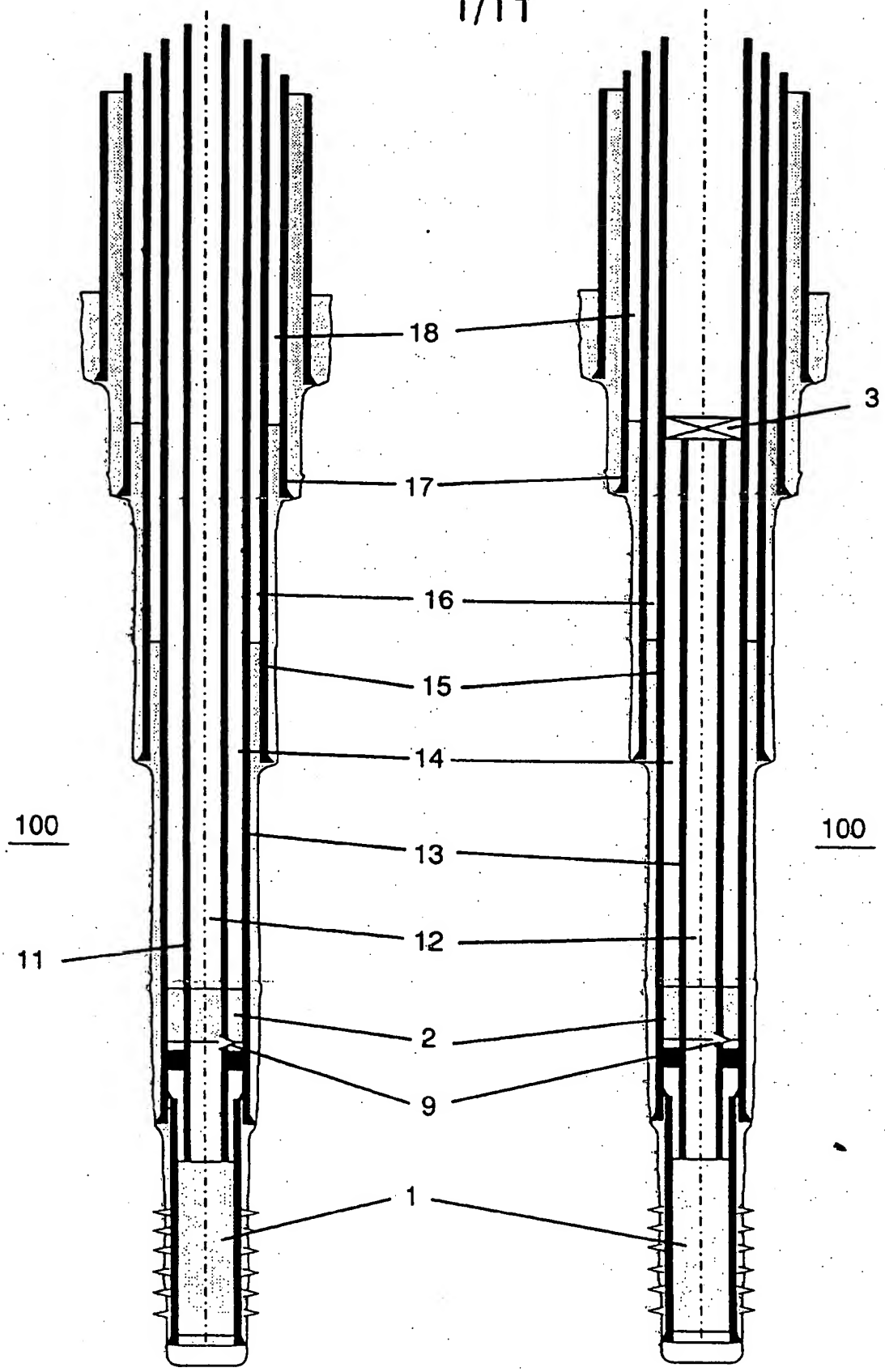

Figure 1

Figure 2

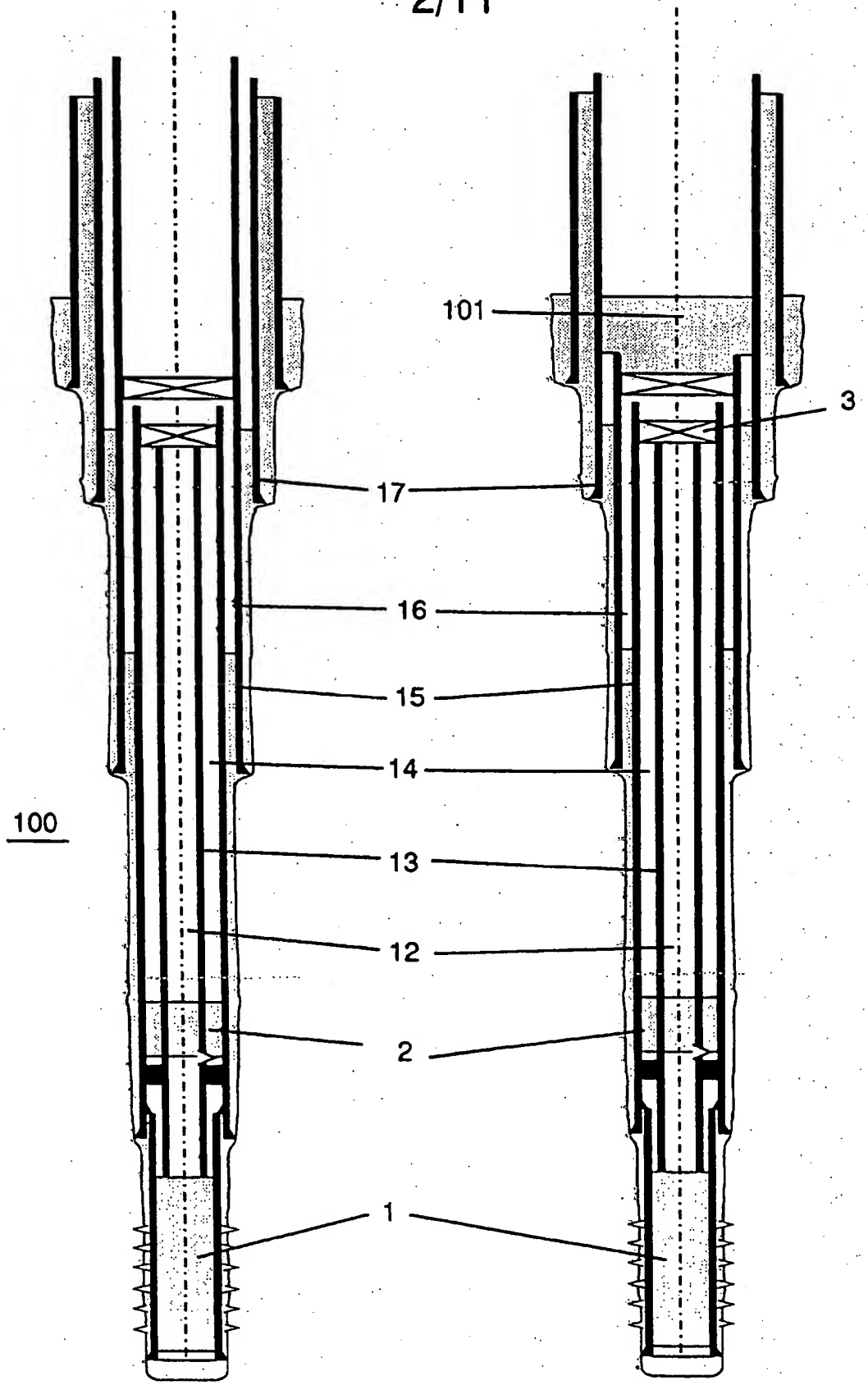

Figure 3

Figure 4

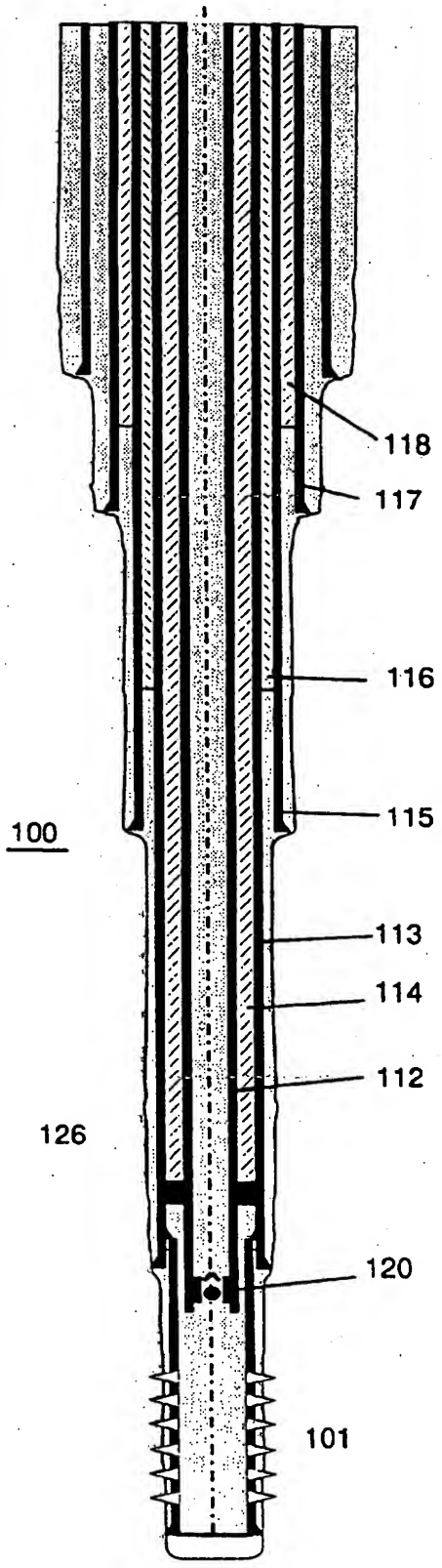

Figure 5

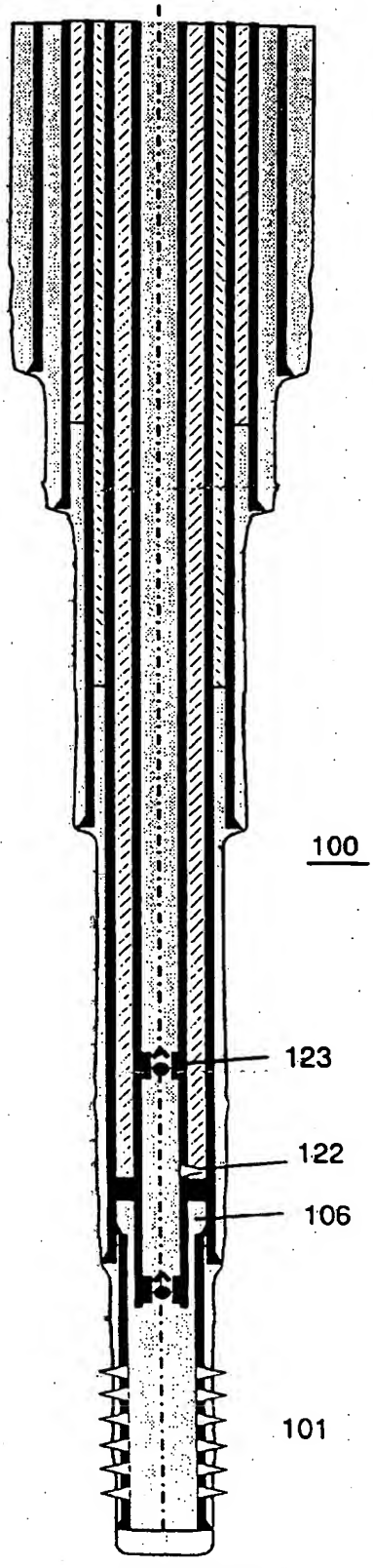

Figure 6

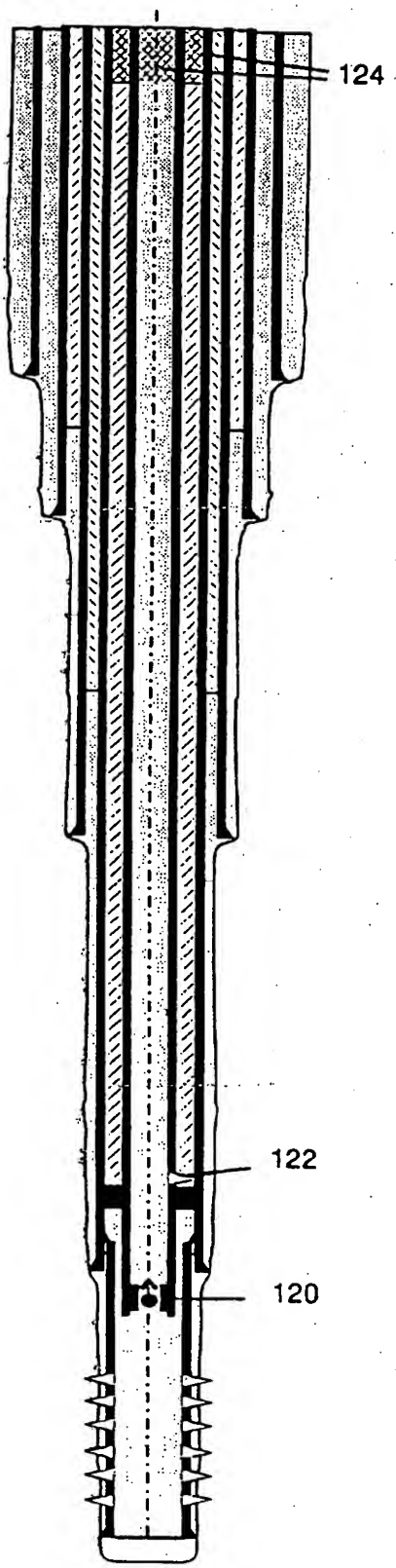

Figure 7

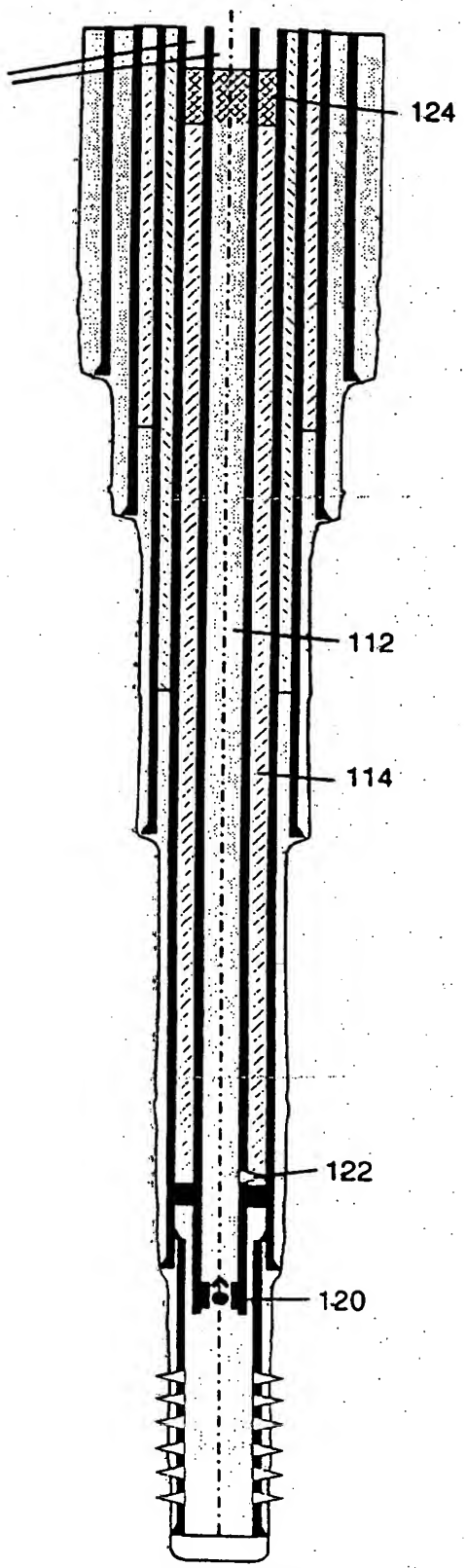

Figure 8

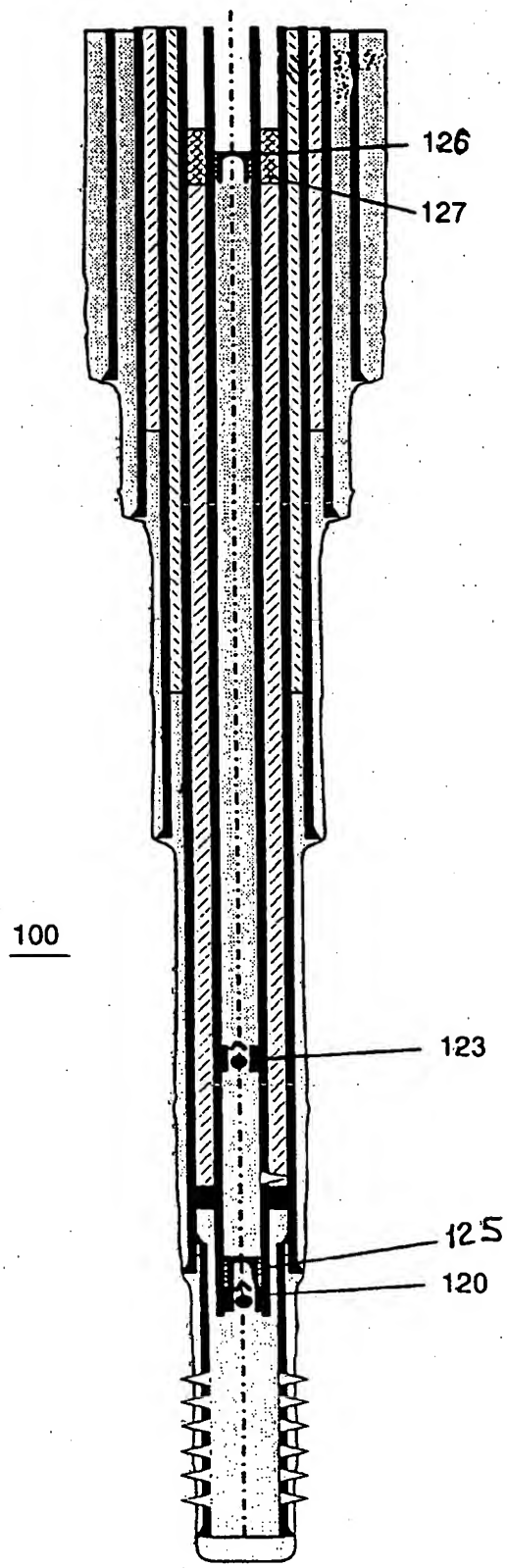

Figure 7A

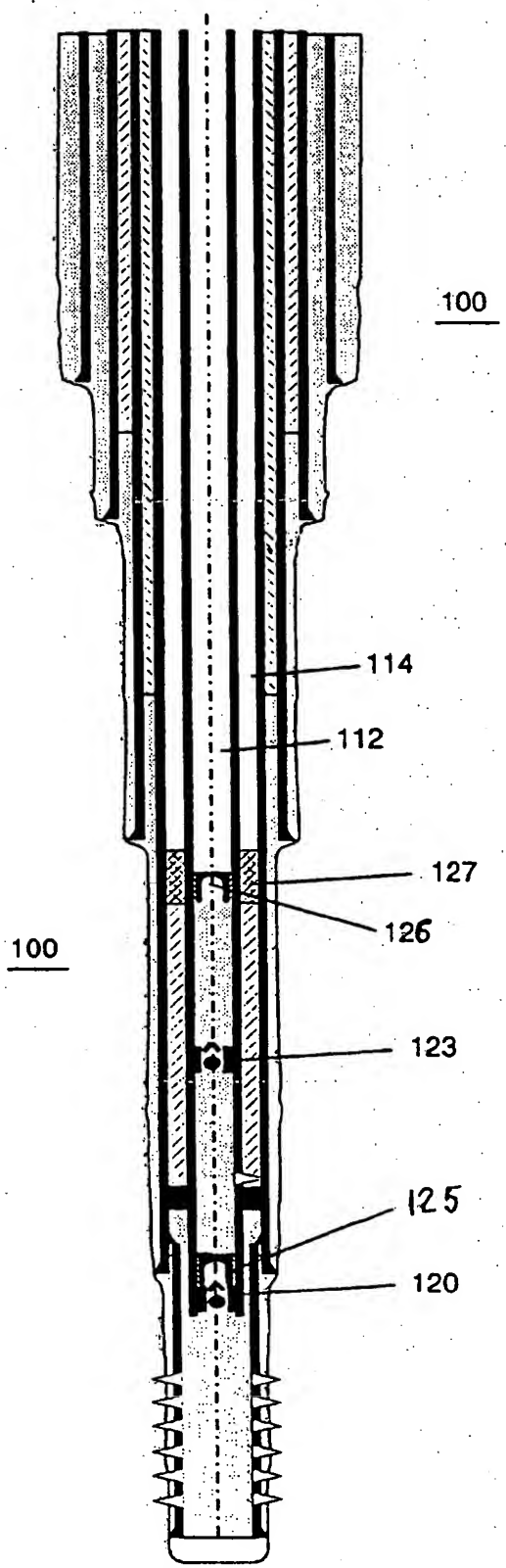

Figure 8A

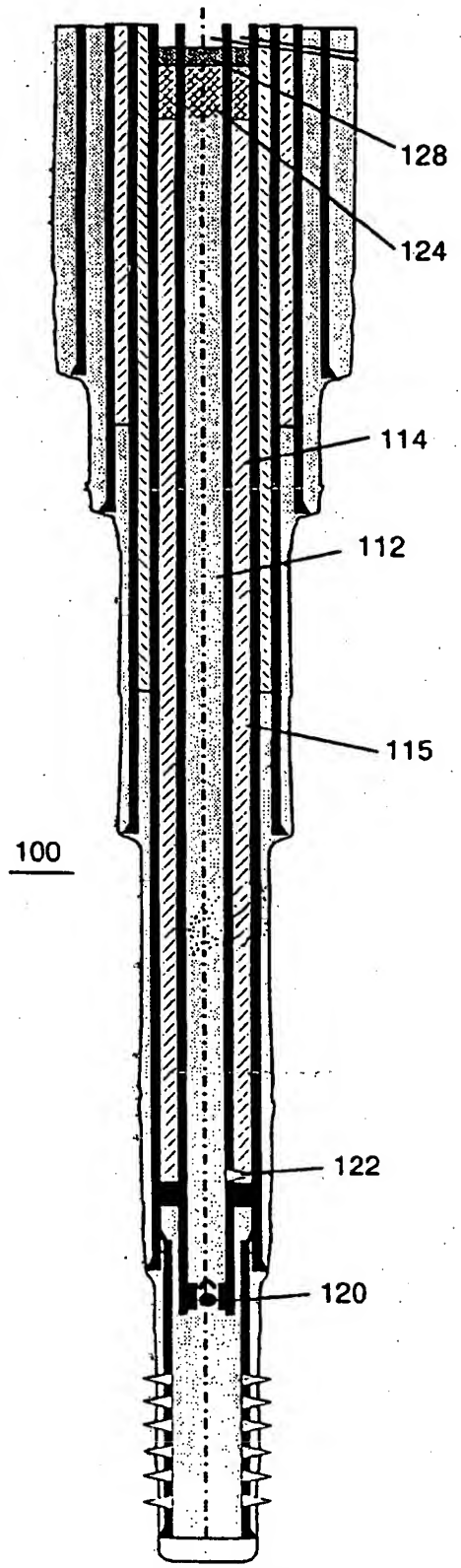

Figure 9

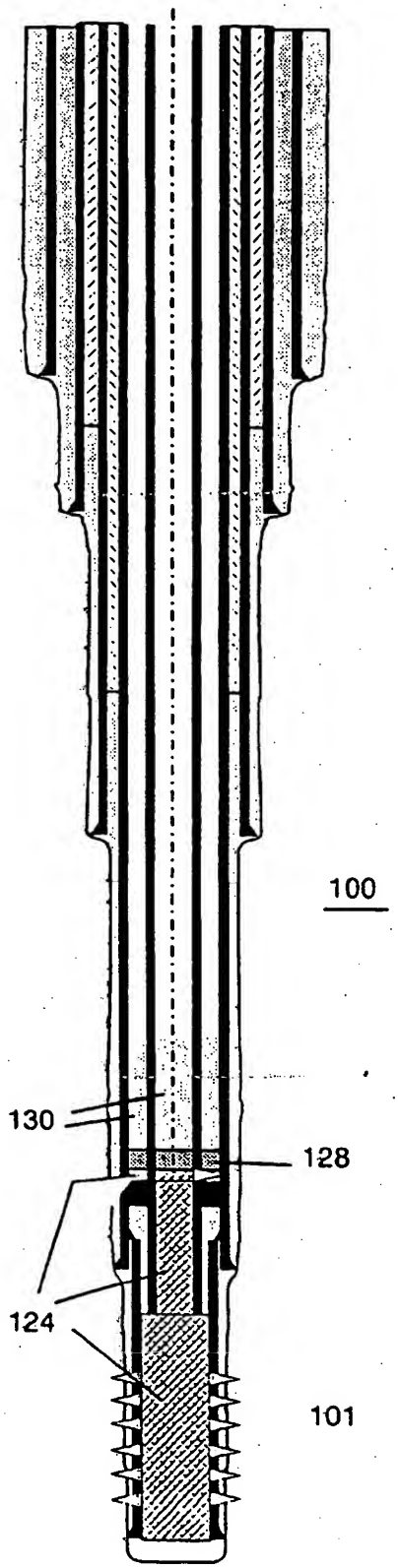

Figure 10

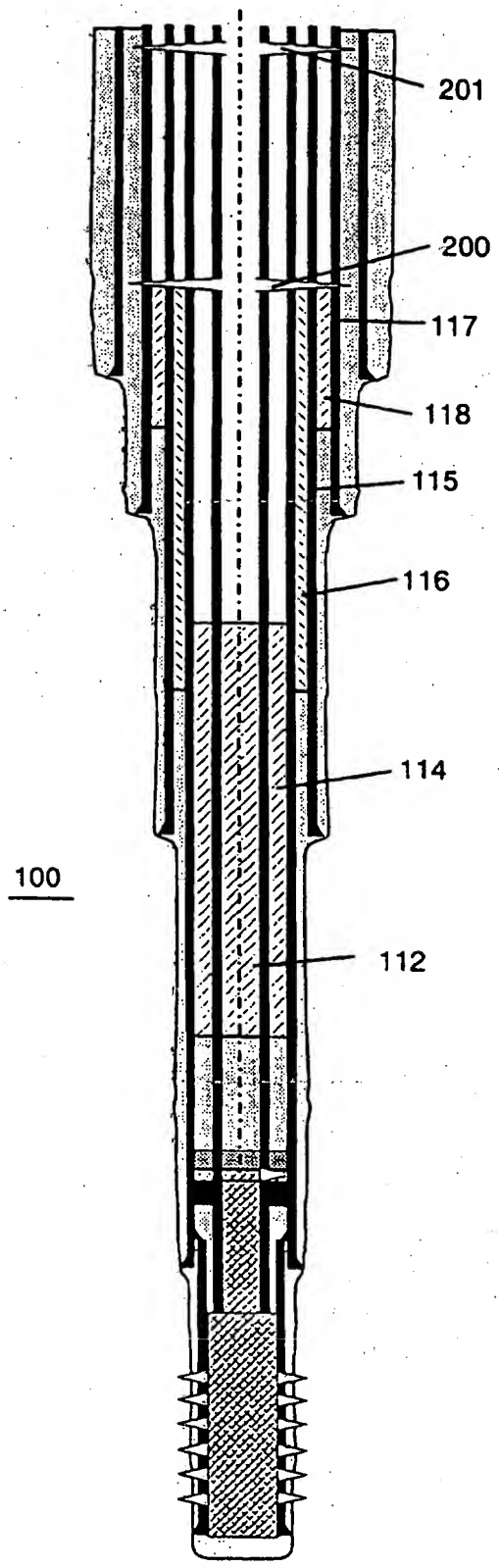

Figure 11

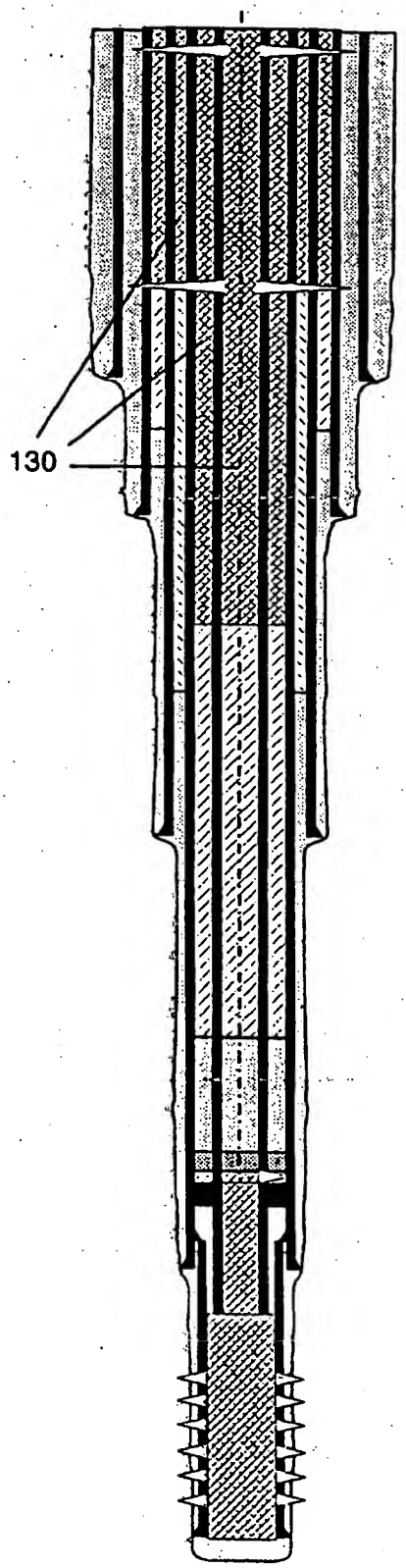

Figure 12

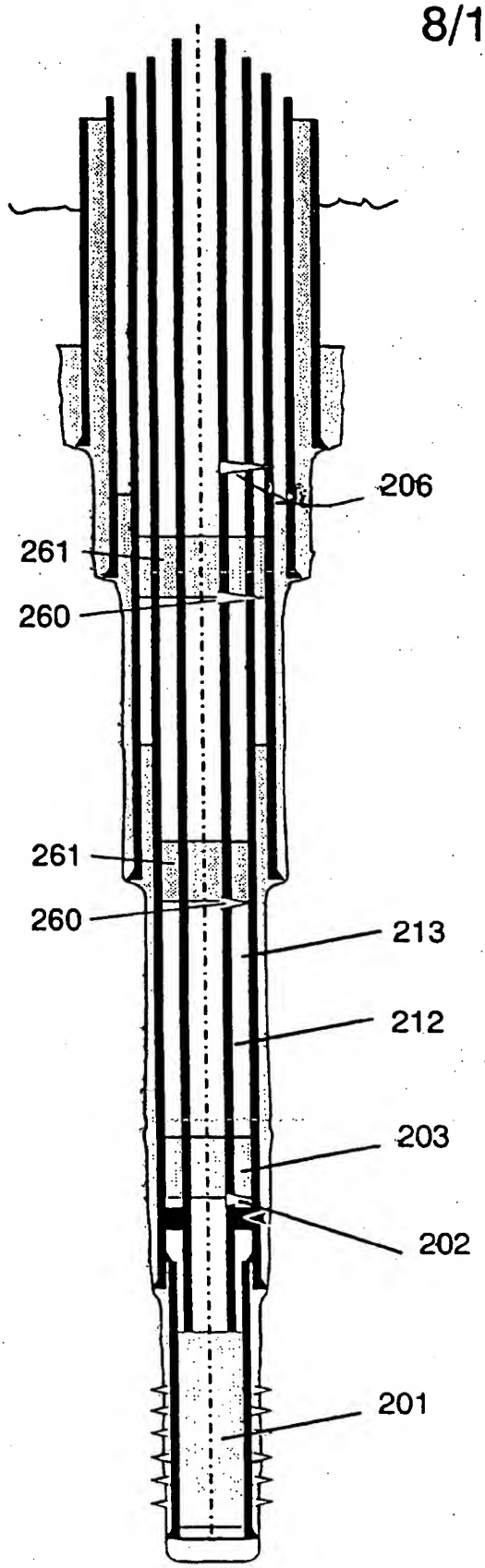

Figure 13

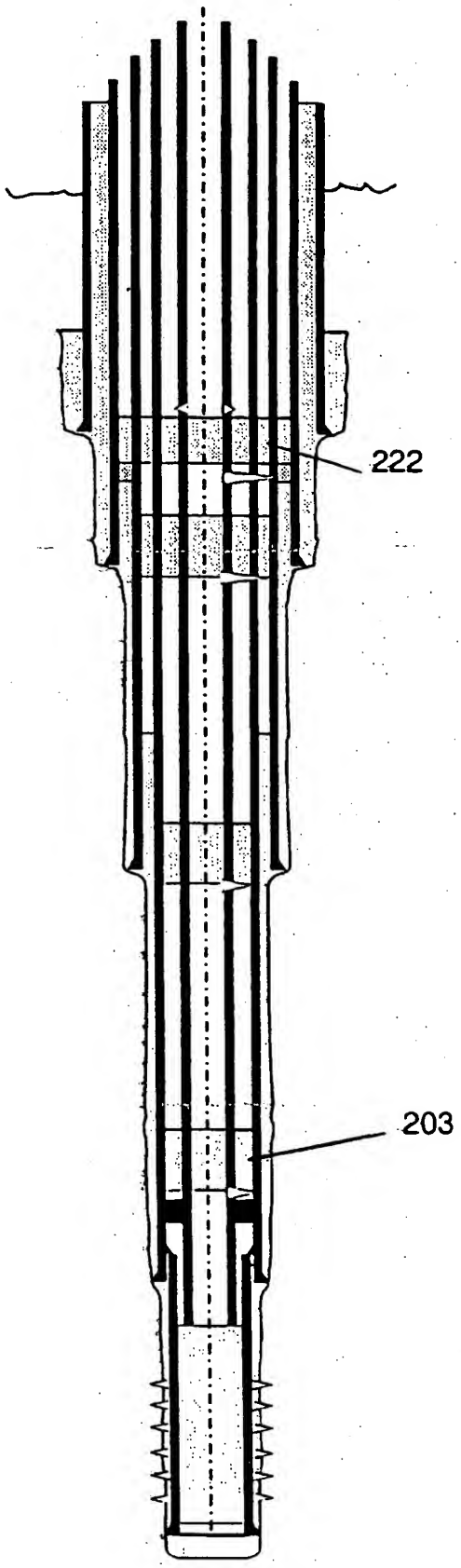

Figure 14

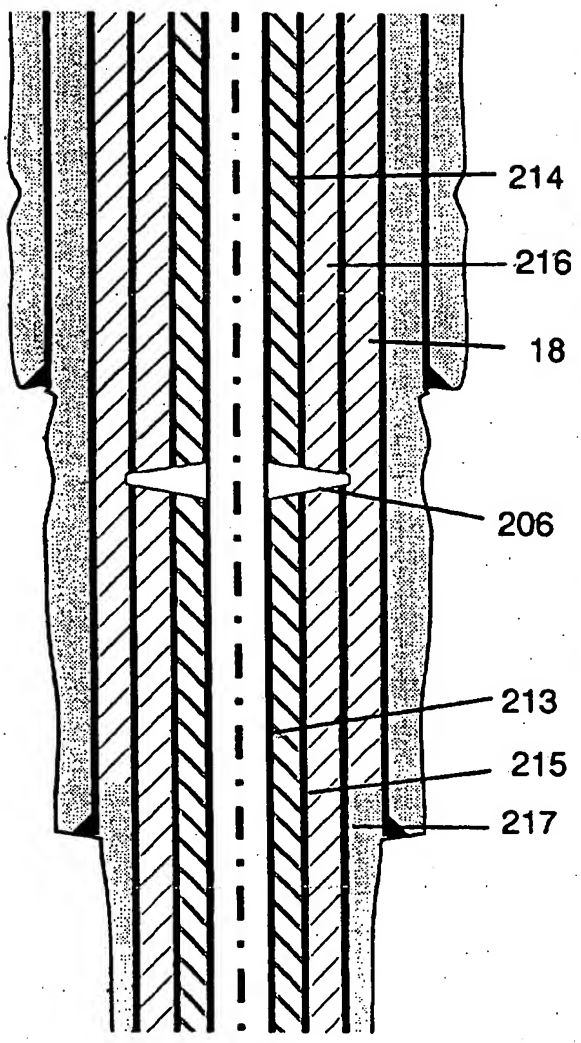

Figure 15

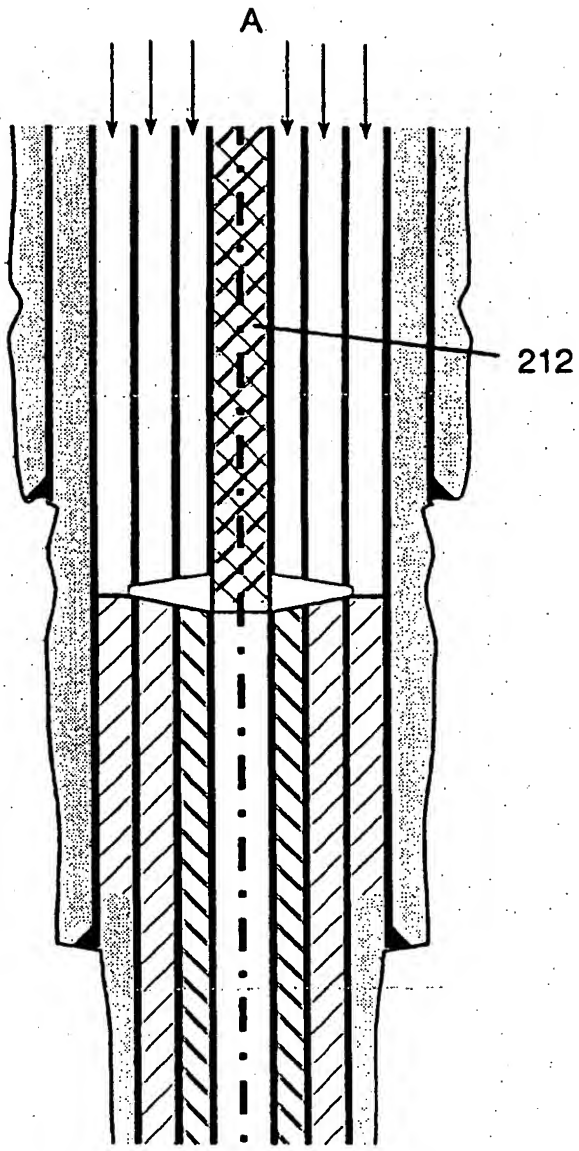

Figure 16

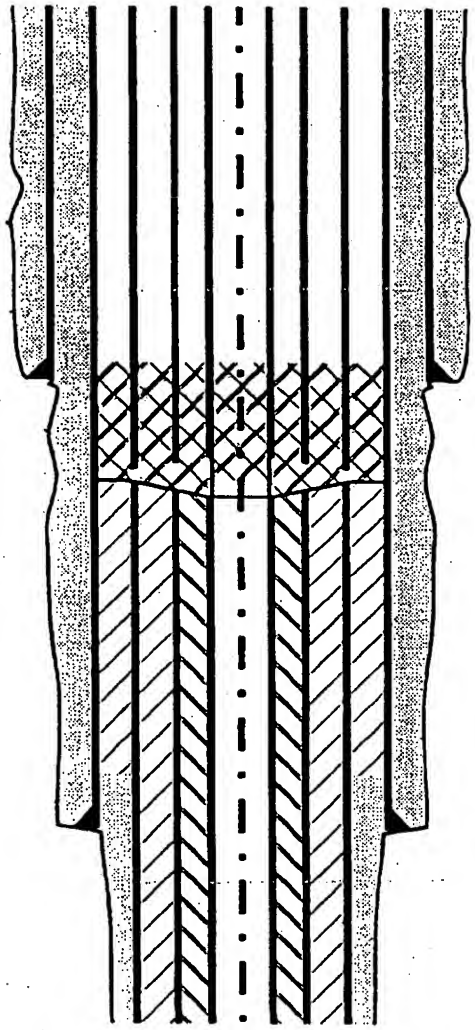

Figure 17

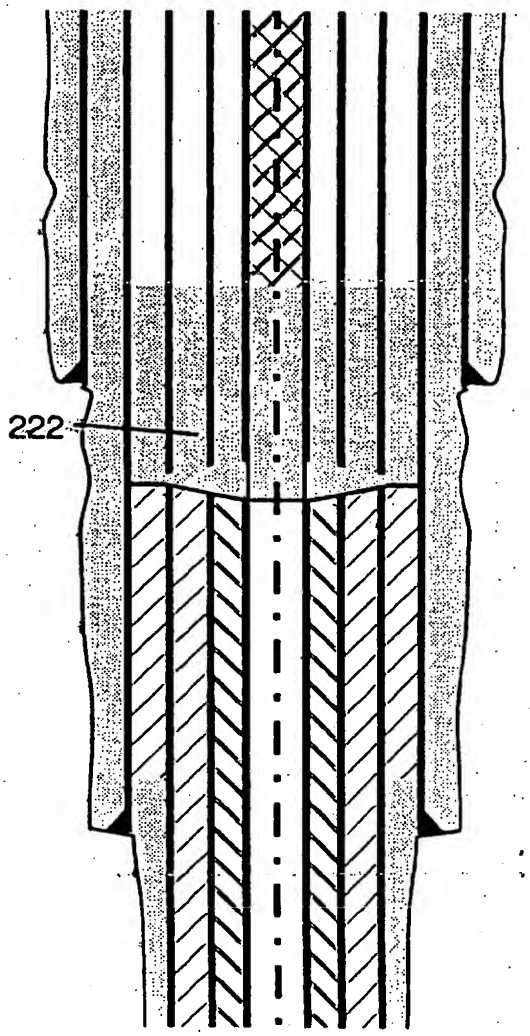

Figure 18

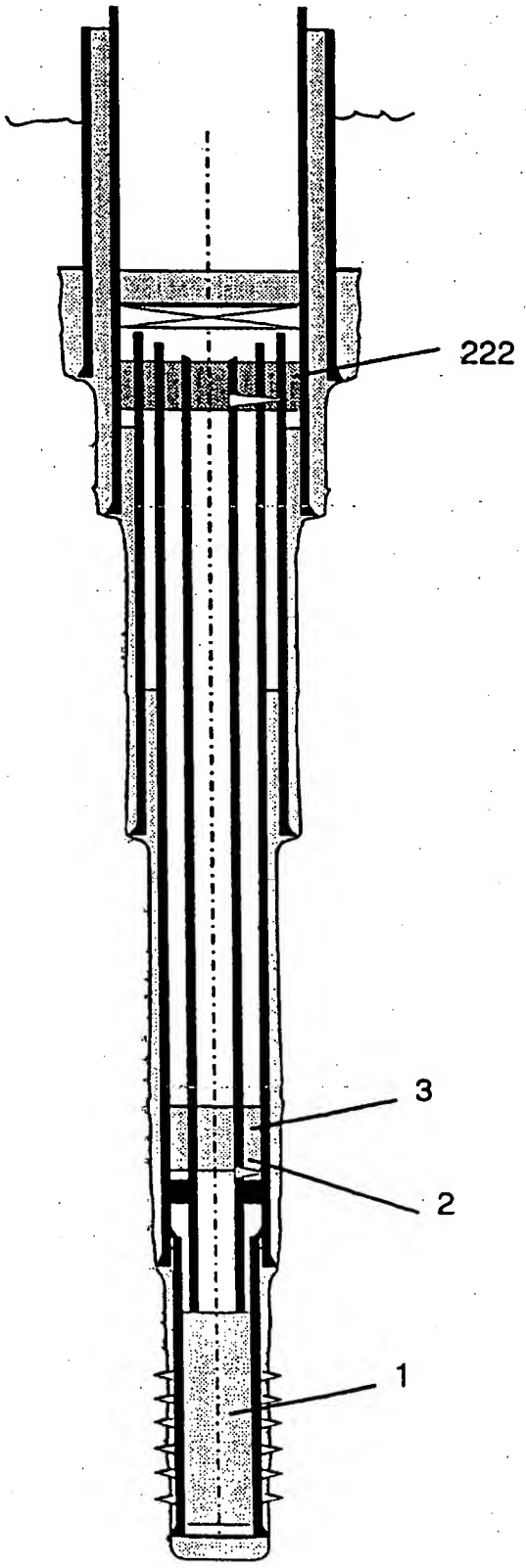

Figure 19

A Method of Abandoning a Well

This invention relates to the abandonment of wells which is required when production has ceased due typically to the production level being so low that the well can no longer be run economically. Oil wells which are typically located offshore usually carry a higher maintenance cost and therefore will reach the point of abandonment sooner than land based oil wells. However the present invention is applicable to land based oil wells as well as to offshore oil wells.

Over the past 20 years or so a large number of offshore structures have been constructed which are now or will soon be exhausted and will need to be abandoned. These offshore structures may comprise production platforms which are either steel or concrete structures resting on the sea bed or floating platforms. Numerous conduits are connected to these offshore structures to carry the various fluids being gas, oil or water etc., which are necessary for the production of oil and/or gas from the well.

In abandoning a well, consideration has to be given to the potential environmental threat from the abandoned well for many years in the future.

In the case of offshore structure there is usually no rig derrick in place which can be used to perform the required well abandonment procedure. Therefore it is typically necessary to install a new derrick or alternatively a mobile derrick can be positioned above the well. This requirement adds considerable expense to the to the task of abandoning the offshore well, compared to a land based well.

A typical production well will comprise a number of tubular conduits arranged concentrically with respect to each. The method of abandoning the well which is presently known in the art involves the separate sealing of each of the concentric conduits which requires a large number of sequential steps.

In the abandonment method known in the art the first step is to seal the first central conduit usually by means of cement or other suitable sealant. The first annular channel between the first and second conduits is then sealed and the first central conduit is then cut above the seal and the cut section is removed from the well.

The second annular channel between the second and third conduits is then sealed and the second conduit cut above the seal and the cut section is removed from the well.

This process is repeated until all the conduits are removed. The number of separate steps required is typically very large indeed and the number of separate operations is five times the number of conduits to be removed. This adds considerably to the cost of the well abandonment due to the time taken and the resources required at the well head.

It is the purpose of the present invention to provide a method of abandoning a well which avoids the disadvantageous and numerous operations which are required by the existing known methods. This will greatly reduce the costs of safely abandoning a well. It is a further objective of the invention to provide a method of abandoning a well without the requirement of a rig which involves significant expense particularly in sea based wells.

It is a further advantage of the invention to isolate all the conduits and annuli with no return of the well bore or annular fluids to the surface. Additionally if required all tubing and casing can remain in the well. Further more the method of abandonment of the well will comply with all the regulatory guidelines for the isolation of a well.

According to the invention for the method of abandoning a well, said well comprising at least two concentric conduits comprising at least one annular channel there between, comprises the steps of:

a. perforating the said at least two of the conduits at the point where the well is to be abandoned,

b. sealing the said at least one annular channel with a suitable sealant.

According to a further aspect of the invention there is a method of abandoning a well comprising the following steps.

a. perforating at least one of the conduits at the point where the well is to be abandoned,

b. purging or flushing the annular channel(s) with a suitable fluid at the required pressure,

c. sealing the annular channel(s) with a suitable sealant.

d. cutting completely through the said at least one conduit,

e. removing the said at least one conduit.

The method of abandoning a well according to the invention also includes that a hydraulic seal is provided, such as by cement being poured into the internal conduit and the annuli after the purging process is complete.

The method of abandoning a well according to the invention may also includes a hydraulic seal provided by a solid plug or a layer of elastomeric material or any other suitable sealing means.

Thus by means of the method according to the invention the number of operations required is greatly reduced thus resulting in a considerable reduction in the cost of carrying out the well abandonment.

According to a further aspect of a perforating device is provided according to the invention to carrying the perforating operation, said perforating device may be adapted to permit the pumping of sealant to the area where the seal is required . The conduits are then removed and a final seal applied to the whole well.

The following is a more detailed description of an embodiment according to invention by reference to the following drawings in which:

Figure 1 is a side view of a typical well showing steps 1 to 2 of a conventional well abandonment,

Figure 2 is the same view as figure 1 showing steps 3 to 5 of a conventional well abandonment,

Figure 3 is the same view as figure 1 showing steps 6 to 10 of a conventional well abandonment,

Figure 4 is the same view as figure 1 showing steps 11 to 14 of a conventional well abandonment,

Figure 5 is a side view of a typical well showing to be abandoned according to a first embodiment of the invention,

Figure 6 is the same view as figure 5 according to a second embodiment of the invention,

Figure 7 is the same view as figure 5 showing a further detail of the first embodiment of the invention.

Figure 8 is the same view as figure 5 showing a further detail of the first embodiment of the invention.

Figure 7a is the same view as figure 5 showing a third embodiment of the invention.

Figure 8a is the same view as figure 5 showing a further step of the third embodiment.

Figure 9 is the same view as figure 5 showing a further step in the method of abandonment of a well according to the invention.

Figure 10 is the same view as figure 5 showing a further step in the method of abandonment of a well according to the invention.

Figure 11 is the same view as figure 5 showing a further step in the method of abandonment of a well according to the invention.

Figure 12 is the same view as figure 5 showing a further step in the method of abandonment of a well according to the invention.

Figure 13 is a side view of a well to be abandoned according to a third embodiment of the present invention.

Figure 14 is a side view of a well to be abandoned showing further steps of the method according to the third embodiment of the invention.

Figure 15 is a more detailed side view of the well in figure 13 in the region of the perforations,

Figure 16 is the same view as figure 15 showing the purging of the well,

Figure 17 is the same view a figure 15 showing a further step of the third embodiment in more detail,

Figure 18 is the same view as figure 15 showing a further step of the third embodiment of the present invention.

Figure 19 is the same view as figure 13 showing further steps of the third embodiment of the invention.

Figures 1 to 4 show a method abandoning a well which is conventionally used. Referring to figure 1 the well comprises a first conduit 11, a second conduit 13, a third conduit 15, a fourth conduit 17 and a fifth conduit 19. Between each of the conduits annular channels 12, 14, 16, 18 are defined.

Referring to figure 2 the following steps are required:

1. A first seal 1 is made sealing the first production conduit 11 from the oil or gas reservoir.

2. A second seal 2 is made between the first conduit 11 and the second conduit 13.

3. The first conduit 11 is cut and removed from the well.

4. A seal 3 is made in the of the internal bore of the second conduit 13.

5. Perforations are made in the wall of the second conduit 13.

6. The contents of the second annual channel by means of suitable flushing material from the well head.

7. The wall of the second conduit 13 is cut.

8. The second conduit is removed from the well.

9. Steps 4 to 8 are repeated for the subsequent conduits.

Thus the total number of operations for the well described in this embodiment comprising merely five conduits is 23. Each step requiring several winching operations from the well head.

As shown in figure 4 a final seal of concrete 101 is made covering all the annular channels.

Referring now to figure 5 and subsequent figures a method of well abandonment is described according to an embodiment of the invention for the same well comprising five conduits.

In the method according to the invention the well fluids are to be pumped by applying pressure by means of a gaseous medium back down the well back into the reservoir. As a precaution, and before the pumping is commences a mechanical check valve 120 is positioned above the reservoir perforations 101 preventing flow from the reservoir. This mechanical check valve allows flow back into the reservoir but does not permit flow out of the reservoir up the production tubing. The purpose of the mechanical check valve 120, 123 is to prevent the return of the well fluids up the production tubing in the event that the pressure is lost for any reason.

Referring to figure 6 it can be seen that a perforation 122 is provided just above the production seal 106. This perforation connects the inner most conduit or production tubing 112 with the first annular layer 114. This allows the fluids in both the inner most conduit 112 and the first annular channel 114 to be pressurised back into the reservoir, provided there is access to the first annular channel further up the well and preferably at the surface. A second mechanical check valve 123 is then optionally provided above the perforation 122 to permit the pressurising of the production tube

112 and the first annular channel in separate stages. The second mechanical check valve 123 is positioned at a determined distance above the first mechanical check valve 120 which will be used to confirm the amount of final hydraulic seal or cement (see below).

Further annular channels can be included in the pressurisation and their fluids pressurised back into the reservoir if access to the annular channel is possible but this is not always the case.

In some cases it is not possible to access the first annular channel at the surface and also in some cases the inner conduit of production tubing 112 is sufficiently wide to contain the fluids drained from the remaining annular channels by means of the further steps of the method of the invention which will now be described. It may also be the case that it is only necessary to drain the first annular channel into the production tubing and the remaining channel can remain in the un-drained condition. This would depend on the nature of the material within the further annular channels.

Referring to figure 7 it can be seen that a hydraulic seal 124 is provided at the top of the inner most conduit or production tubing 112 and the first annular channel 114. The delayed acting hydraulic seal 124 is of a material which is flexible enough to slide down the production tubing whilst maintaining a seal. The seal may be provided by a delayed action cement or a suitable cross linked polymer. The seal could also conveniently be a solid plug type seal which seals as it moves down the well for example by means of rubber fins. The seal 124 forces the well fluids down the production tubing 112 and the first annular channel 114 by means of pressure applied above the seal 124. The medium by which the pressure is applied is a gaseous medium 126 such as nitrogen as shown in figure 8.

As shown in figure 9, if required, an elastomeric layer 128 may be provided above the seal 124 to prevent the sealing material from attaching itself to the side walls 113, 115 of the production tubing 112 and the first annular layer 114.

Alternatively, referring to figures 7a and 8a, the well fluids are pressurised by a gaseous medium and hydraulic seal means are provided ahead of the pressurising gaseous medium such as a plug 125 or viscous gel 127 to ensure that the residual well fluids are pushed down, through the check valves 120, 123, into the reservoir. In the annular channel 114 for which it is not so easy to provide a plug of the required dimensions a flexible plug made of a viscous gel 127 such as can be provided by a cross linked gel can be used which has the desired effect of pushing the fluids down the annular channel with the pressurised gaseous medium behind it.

Once the well fluids have been forced down through the mechanical check valve 120, 123, as far as the reservoir perforations 101, cement is then pumped down. The plug 125 is preferably a burst disc assembly which permits the cement to pass through the mechanical check valve(s) 120, 123 and into the lower part of the well. In the case of the hydraulic seal being a viscous gel the seal is forced through the mechanical check valve. A predetermined volume of cement is pumped according to the calculated volume of the well area in the region of the reservoir perforations 101 and of the inner conduit and first annular conduit up to the second mechanical check valve. The second mechanical check valve will typically be paced above the first mechanical check at a distance to ensure that the required amount of cement is provided in the inner conduit 112 and first annular channel 114. Such a distance would typically be 100 feet.

Immediately behind the cement a further plug 129 is pumped down. When this plug lands on the second mechanical stop valve 123 this can be detected at the surface by the indication of a sudden pressure build up and the pumping can be stopped. This will indicate that the cement has fallen down far enough to fill the required area in the region of the reservoir perforations 101 and also the required 100 feet of the inner conduit 112 and the first annular channel 114. The level of the cement in the first annular channel 114 will be approximately the same as the level of cement in the inner conduit 112. If additional cement is required in the first annular channel 114 then the required amount can be added.

Once the cement has set it can be pressure tested for any leakages into the reservoir to confirm that the well abandonment has been completed successfully.

An empty space is thus created in the production tubing 112 and the first angular channel 114. According to this embodiment of the invention this space is now used as a sump in which the fluids contained in the remaining annular channels 116, 118 etc. can be drained.

Thus referring to figure 11 it can be seen that by perforating through the further conduit walls 115,117 etc. the fluids in the remaining annual channels are permitted to flow into the space in the production tubing 112 and first annular channel 114. The perforations are made further up the well at point, which can be accurately calculated, at which there is sufficient volume in the production tubing 112 and first annular channel 114 to contain all the fluids contained in the remaining channels.

Referring to figure 12 it can be seen that a further seal 130 can then be provided across all the channel of the well, which are now inter connected by means of the last perforations, so that the entire well is completely sealed.

Thus by reference to figures 5 to 12 one embodiment of the method of abandoning a well according to the invention is as follows:

1. Position first mechanical check valve 120.

2. Pressurise inner conduit 112 with nitrogen through mechanical check valve 120 into the reservoir by means of a burst disc plug assembly.

3. Perforate the inner conduit 112 immediately above the well packer.

4. Position second mechanical check valve 123 100 feet above first mechanical check valve 120.

5. Introduce second burst disc plug 126 and pump cross linked gel 128 into the first annular channel 114.

6. Pressurise the inner conduit 112 and the first annular channel 114 simultaneously contents with nitrogen until the second plug lands on the second mechanical check valve 123.

7. Pump cement into the inner conduit 112 and first annular channel 114 using a third plug and a cross linked gel in the annular channel if necessary.

8. Pressurisation of the cement is continued until the third plug lands on the second plug. Test when set.

9. Perforate all upper conduit to drain all remaining annular channels into the nitrogen sump formed by the inner conduit and the firs annular channel.

10. Pump cement into all upper annular channels. Test when set.

If necessary all the conduits can then be removed above the final seal 130 by any suitable known means.

A further embodiment of the present invention is shown in figures 13 to 19. In this embodiment the production tubing 212 is sealed and removed in the same way as is presently known. The subsequent steps of the conventional method are re-placed by the following steps of the method according to the invention:

As shown in figures 13 and 15, at a suitable location perforations 206 are made in all of the remaining four conduits using a suitable perforating tool which may be lowered on a wire line in a known way.

As shown in figure 16 a purging material such as nitrogen is then pumped down the remaining annular channels from the well head in the direction of the arrows A to displace the contents of the annular channels through the perforations and up through the central channel 212 for safe removal without effecting the environment.

Cement is then pumped down the annular channels from the well head thus providing a seal across all the annular channels in the region of the perforations 206. Thus the whole well can be made completely safe in one application of concrete 222 as shown in figures 17 and 18.

All the remaining conduits can then be cut and removed one by one by any suitable known manner.

Thus it can readily be seen that by means of the method of well abandonment according to the invention the time and number of separate operations required for completion of the abandonment of a well compared to the conventional method are considerably reduced.

Referring to figures 13 and 14 in conjunction with figure 15, according to this embodiment a means is required for pumping cement to the required location following perforation and this may be provided by means of a combined perforating and plugging device as follows:

a. The conduit perforating and plugging device is lowered to the position in the central conduit where the cement plug is required,

b. the conduit wall is perforated,

c. the central conduit is sealed at the well head to prevent back flow of the sealing cement,

d. the annular channel in which the cement plug is to be located is left unsealed at the well head to permit the cement to pass through to the annular channel,

e. cement is then pumped through the perforations in the conduit wall to form the required plug displacing the material present.

Sealant may be pumped in the region of the central conduit surrounding the conduit perforating and plugging device and left to form a balanced plug across the central conduit as the conduit perforating and plugging device is removed.

It will be apparent to any one skilled in the art that a plug may be formed at any annular channel by continuing the perforation through as many conduit walls as required at any required position in the well. The plug will be formed by pumping the required amount of cement to the required location with the appropriate annular channels either sealed or left open at the well head.

CLAIMS

1. A method of abandoning a well, said well comprising at least two concentric conduits 213, 215, 217 comprising at least one annular channel 214 there between, and an innermost channel 112, which contain well fluids and other fluids associated with oil or gas production, characterised in that it comprises the steps of:

   a. perforating the said at least two of the conduits 213, 215, 217 at the point where the well is to be abandoned,

   b. sealing the said at least one annular channel 214 with a suitable sealant.

2. A method of abandoning a well according to claim 1, comprising the following steps.

   a. perforating at least one of the conduits 213, 215, 217 at the point where the well 200 is to be abandoned,

   b. purging or flushing the annular channel(s) 214, 216, 218 with a suitable fluid at the required pressure,

   c. sealing the annular channel(s) 214, 216, 218 with a suitable sealant,

   d. cutting completely through the said at least one conduit 213, 215, 217

   e. removing the said at least one conduit 213, 215, 217.

3. A method of abandoning a well 100 according to either claim 1 or claim 2, characterised in that a hydraulic seal 222 is provided in the internal channel following purging of the oil well fluids.

4. A method of abandoning a well 100 according to either claim 1 or 2, characterised in that a hydraulic seal 222 is provided in at least one of the open channels 213, 215, 217.

5. A method of abandoning a well according to claim 3 or 4 characterised in that a further second hydraulic seal is applied on top of the existing hydraulic seal 222 to complete the sealing of the well 100.

6. A method of abandoning a well 100 according to any of the preceding claims 3 to 5 characterised in that the hydraulic seal 222 is cement.

7. A method of abandoning a well 100 according to any of the preceding claims 3 to 5 characterised in that the hydraulic seal 222 is a solid plug seal.

8. A method of abandoning a well 100 according to claim 1 or 2, characterised in that following purging, cement is applied to the well in a gaseous medium.

9. A method of abandoning a well according to any preceding claim, characterised in that the material used for purging the annular channels is nitrogen.

10. A method of abandoning a well according to any preceding claim, characterised in that the well is provided with a further seal after all the conduits 210, 212, 214, 216 have been removed.

The Patent Office

—

Application No: GB 9700421.2
Claims searched: 1 to 10

Examiner: David Harrison
Date of search: 10 February 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): E1F (FJU, FLA)

Int Cl (Ed.6): E21B

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,E	GB 2279092 A	(Head) 21 December 1994; Whole document	1-10
X,E	GB 2275282 A	(Halliburton Company) 24 August 1994, Whole document, but see particularly Figure 6.	1,4,5,6,10
X	US 4688640	(Pritchard)	1
A	US 4339000	(Cronmiller)	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.